Situational Awareness at Different Levels of Abstraction: The Distributed Cooperative Problem-Solving Domain of ATCSCC-Airline Operations

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Abstract

Situational awareness is most frequently considered as it pertains to an individual's goals and tasks. Distributed and cooperative problem-solving presupposes that the tasks and goals are not only being considered at the level of the individual's perception, but that the task and goals of the larger task group are being cooperatively addressed. Within the three worlds of flight deck, ATC, and airline operations, individuals shift their efforts to help others achieve success, resulting in a team mentality in which the concern becomes how to help the system work better while optimizing individual goals. The distributed, cooperative problem-solving of ATCSCC-Airline Operations is examined as an illustration of how situational awareness can be maintained at different levels of abstraction within a distributed cooperative, problem-solving domain.

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Introduction

When moving from examining situational awareness of isolated individuals to studying individuals responsible to a distributed, cooperative problem-solving domain, the issue of levels of abstraction becomes an important consideration.

In a cooperative problem-solving domain, individuals who have learned the degree of background knowledge and experience of their counterparts develop a sense of trust in these other individuals. Unless a less than satisfactory solution to a problem is provided that conflicts with the assessment of the individual, little additional detailed information is needed or sought. In instances in which the other individual is unknown or the proposed solution conflicts with the first individual's assessment, then more detailed information may be sought relative to the problem. Thus, depending on the circumstances, the necessary level of detail needed to maintain situational awareness will vary.

In the authors' long term study of the aviation system, the relationships of airline operations control (dispatch) and Air Traffic Control System Command Center (ATCSCC) seem to illustrate such shifting levels of abstraction.

ATCSCC-Airline Operations

Airline Operations. Airline operations (dispatch) task characteristics reflect a distributed, cooperative problem-solving environment. Knowledge and data are distributed among a number of individuals. Dispatchers need to coordinate and cooperate with individuals who have differing goals and constraints, including traffic management specialists at ATCSCC and at the Traffic Management Units at the Enroute Centers, flight crew, and other staff within the airline operations center. Airline dispatchers must work cooperatively with other airline and ATC staff who are geographically distributed to accomplish preflight planning and enroute amendments.

Under FAR 121, a Dispatcher and a Captain are jointly responsible "for the preflight planning, delay and dispatch release of a flight." The Dispatcher is also responsible for monitoring the progress of each flight, issuing necessary information for the safety of the flight, and canceling or redispatching a flight if in his/her opinion or in the opinion of the pilot in command, the flight cannot operate or continue to operate safely as planned or released. From an airline management perspective, the Dispatcher is also concerned with factors such as cost, timeliness and passenger comfort.

ATC Coordinators work within the airline operations control centers and are typically experienced Dispatchers who function in a special role as liaisons to ATCSCC and the Enroute Centers.

ATCSCC. ATCSCC is the strategic planning organization for the ATC system, dealing with the airline operations control staff (often through the airline's ATC coordinator) and with the Enroute Centers to plan daily traffic (including replanning flights to deal with weather, airport

problems, etc.) ATCSCC has a number of specialist positions for dealing with specific components of this strategic planning, including a position to deal with airline requests for route changes for particular flights.

In the evolution of collaborative airline-ATCSCC communication, certain new procedures have been developed and integrated so as to encourage cooperation. The goal in adopting these procedures has been to improve the efficiency and timeliness of flights, while maintaining or improving safety, thus resulting in lower costs and better service for passengers and cargo delivery. The factors influencing the effectiveness of these new procedures, though, appear to be fairly complex.

Requesting Non–Preferred Routes

The role of situational awareness and the individuals' shifting need for details at differing levels of abstraction in a distributed and cooperative problem solving environment is evident in the evolution of the process by which dispatchers can request non–preferred routes for their flights (McCoy, Smith, Orasanu, Billings, VanHorn, Denning, Rodvold, Gee, 1995).

As part of the National Route Program (NRP), many commercial airline flights are assigned a preferred route by ATCSCC although airlines can request alternatives. Traditionally, a somewhat cumbersome procedure requires that requests for non–preferred routes must be submitted to ATCSCC via teletype. The ATCSCC staff member responsible for such requests then contacts the necessary Enroute Centers by phone to see whether they can accommodate the request. Some requests, or portions of requests, may match a list of non–preferred routes that can be automatically approved without contacting the affected Center. If a request for a segment of a route is denied by a Center, that Center may suggest an alternative.

Once all of the affected Centers have been contacted, the ATCSCC staff member informs the ATC Coordinator or Chief Dispatcher at the airline or in some cases an individual Dispatcher who made the request, communicating by phone or teletype regarding its approval, proposed modification or disapproval. The reasons behind a proposed modification or disapproval may or may not be given. Finally, the relevant Dispatcher at the airline must concur with the ATC Coordinator that the approved route is viable.

Current communication by telephone allows for much richer interactions and makes it more likely that personal ties will develop, enhancing cooperation and trust. Explanations can be requested or offered when the need arises for additional detail. One measure of success is financial. One airline reports that it saved $4.3 million in fuel costs in one year: "Last year the non–prefs saved our airline $4.3 million. Our upper management finally came back and said: How can 2 guys in the Dispatch Office save this much money? .... We proved it and they told us to hire another ATC man." (McCoy, et al., 1995)

The success of the non-pref route program has been achieved even though the technologies used for this particular program have been rather unsophisticated. The cooperation and communication of the individuals has created a domain of situational awareness that draws

from the knowledge and expertise of the participants who collectively constitute an awareness of parameters that are more global than the parochial concerns of the individuals immediate responsibility.

Factors Related to Levels of Abstraction that Help the System Work

Task allocation. Assignment of an ATCSCC staff member to the task of approving or disapproving routes as his or her sole responsibility on a shift is likely to encourage that individual to adopt as a personal goal creating ways to get non–pref routes approved. In addition, because this person is focusing on this one task, he or she is more likely to develop an understanding of the motivations and behaviors of the ATC Coordinators or Dispatchers making requests.

Similarly, assigning ATC Coordinators the task of interacting with ATCSCC makes it more likely that these individuals will develop an understanding of the procedures and constraints that the ATCSCC specialist must deal with. Equally important, because a relatively small number of individuals is involved in direct communications (at ATCSCC and the airlines), the individuals are more likely to develop a stronger interpersonal bond and a sense of shared goals. Trust may be established and maintained that will reduce the need for additional levels of detail.

Distribution of knowledge. To work as an effective task group, certain knowledge must be shared (Orasanu & Salas, 1993). This question becomes what level of abstraction is needed or desirable. ATC Coordinators who generate non–pref requests are continually in this milieu. Because communications involve discussions of why requests have been rejected, the ATC Coordinators begin to learn what routes are viable as requests. They therefore begin to limit their requests appropriately. One ATC Coordinator commented:

> When we started this, even Central Flow didn't know where all the choke points were. But as we pressed the system and said 'now we want to fly over here', we'd call the Albuquerque Center and they'd say: 'Well, you can't go eastbound over St. John at 4 o'clock in the afternoon'. Well, that was tribal knowledge in the Albuquerque Center. The tribe expanded to include Central Flow; Central Flow expanded the knowledge to the airlines and we began to build better routes. So rather than having to fly a 2000 mile route because it didn't work at one point, we began jogging around and making routes that were smarter (McCoy, et al., 1995).

Distribution of Responsibilities. The distribution of tasks contributes to this successful collaboration as well. Four groups of individuals are directly involved in selecting non–pref routes: staff at the Enroute Centers, the non–pref route specialist on duty at ATCSCC, ATC Coordinators at the airlines and Dispatchers at the airlines. Meteorologists at the airlines and at ATCSCC also provide information.

Since each individual has a different set of primary goals and responsibilities, and makes use of different sources of data, the system provides checks against bad decisions. Local situation

assessment comes into play as information is relayed at a higher level of abstraction. Another local situation assessment is occurring with the other party and may conflict. That individual may then interrogate for greater detail. The Dispatcher in charge of a flight, for example, may point out to the ATC Coordinator that the approved non–pref route is questionable in terms of weather. Similarly, the ATC Coordinator may point out that the route proposed by ATCSCC is impossible because of increased fuel requirements.

Thus, because tasks, information, and workload are distributed (with some redundancy), it is more likely that good solutions will be discussed, and that poor solutions will be detected (Orasanu, Wich, Fischer, Jobe, McCoy, Beatty, Smith, 1993).

Implications

Situational Awareness is enhanced by understanding the goals of the parties with whom one interacts. The three worlds of flight deck, ATC, and airline operations shift to help others achieve their individual goals. A task-group mentality is developed and the concern expands to how to make the system work better.

In order to work efficiently and effectively as a task group, it is important for various members to understand what others are trying to do, how they are doing it, and how and why they have arrived at particular conclusions. This need for a particular level of abstraction varies.

To study the implications of situational awareness for cooperative problem–solving, a broader conceptual framework needs to be considered. The "situation" must be defined not only by available real–time information, but also by background knowledge held by all participants. Successful cooperation is affected by longer term processes that provide feedback to the system, as well as by immediate interactions. While tasks and information may be distributed, when goals and priorities differ among the participants, there needs to be a shared understanding of the local situations faced by each of the individual participants in order to support cooperation. Interpersonal bonds that develop through communication and experience with other task-group members establish a differing thresholds for the need for detailed knowledge regarding decision-making. As trust and understanding increase so does the level of abstraction at which interactions occur.

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